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PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO THE MANUFACTURE OF TAMPONS

(71) We, KARL RUGGLI AG, a Swiss Body Corporate, of Im Berg 50, CH-6435 Fisibach, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to machines for the manufacture of tampons, particularly for feminine hygiene.

Machines for the manufacture of tampons have been known for a long time, for example from US Patent Specification No. 2,798,260. This known machine has the disadvantage that the tampons produced thereby have inadequate resistance to buckling, and therefore on insertion or attempted insertion they buckle. It therefore became necessary to develop processes, such as are described, for example, in German OLS 1,491,161, for operating this known machine to reduce this tendency of the tampons to buckle.

According to the present invention there is provided a machine for manufacturing tampons, by pressing a substantially cylindrical elongate blank of wound wadding fleece in directions generally radially to the axis of the blank, the machine comprising a set of *n* first pressing dies, *n* not being 1 or 2, disposed around a central axis and pivotally movable towards said central axis to a compression position, each first die having two arcuate pressing surfaces respectively of concave and convex form which converge at an inclined angle of 360°/n towards a pressing edge extending parallel to said central axis, the mutually facing pressing surfaces of each adjacent pair of dies defining therebetween an arcuate gap when the dies are in their compression position; a set of *n* second pressing dies equal in number to the first pressing dies, arranged alternately with the first pressing dies around the central axis and also pivotally movable towards the said axis, each second die being movable within one of the said arcuate gaps and having a concave pressing surface facing the central axis formed by a groove extending parallel to the said central axis; first and second drive means for respectively moving the first and second pressing dies towards said central axis; and first and second coupling means for coupling the dies within each set together so that corresponding points in each die within a set are at equal distances from the said central axis; all first and second pressing dies being mounted for pivotal movement towards the said central axis about pivot axes parallel to the central axis, each first and an adjacent second pressing die sharing a common pivot axis, the said pivot axes being spaced at a distance R from the central axis and at a distance

$$2R \sin \frac{\pi}{n}$$

from adjacent pivot axes, wherein R is greater than

$$\frac{D}{2}$$

and at least

$$\frac{D}{4}\left\{ k + (1 + \sin \frac{\pi}{n} \right\} c^2/k \ ,$$

each convex surface of each first pressing die having a centre of curvature coincident with the pivot axis of that pressing die and a radius of curvature of at least p . R and extending for an angle of arc of at least α_{min} where

$$\alpha_{min}=\text{arc cos}\left\{\frac{1}{2}\left(p+\frac{1}{p}\right)-\frac{d}{p}\right\}-\text{arc sin } q,$$

and the concave surface having a radius of curvature of at least

$$\left\{p+2q\tan\frac{\pi}{n}\right\}R,$$

each second pressing die being an arcuate sector of an annulus, having a wall thickness of at least

$$2q\tan\frac{\pi}{n}.R,$$

the concave and convex surfaces of each second die having radii of curvature of at least p . R, and

$$\left\{p+2q\tan\frac{\pi}{n}\right\}R,$$

respectively with both surfaces having a centre of a curvature coincident with the pivot axis of the die, the groove of the concave pressing surface of each second die having a depth of at least (b−q) R, wherein

$$p=\sqrt{1-q^2}-q\tan\frac{\pi}{n}$$

and

$$q=a\cos\frac{\pi}{n},$$

and furthermore $a=r_i/R$, $b=r_a/R$ $c=2r_i/D$, $d=D^2/8R^2$ and

$$k=\frac{1-c\sin\dfrac{\pi}{n}}{1-\sin\dfrac{\pi}{n}},$$

while D is the diameter of the blank, and r_i is the smallest and r_a the greatest distance between the external surface and the centre of the fully compressed tampon.

A two part punch is provided for loading and unloading the machine which is preferably disposed coaxially with the central axis and movable along this axis. It comprises an inner cylindrical punch member having a diameter of at least $2r_a$, and a hollow outer cylindrical punch member 4. Drive means are provided for the punch whereby either both punch members can be moved together for loading a tampon blank in the machine or the inner punch member can move alone, when ejecting a compressed tampon from the machine.

The invention further provides a method of manufacture of a tampon using a machine according to the invention which comprises positioning the first and second dies outwardly from the central axis, displaced at an angle of at least α_{min} relative to their compression positions the second dies being displaced at an angle which is less than the arc angle defining the concave pressing surfaces of the first dies, pushing a blank into the central space between the pressing dies, pivotally moving the first dies inwards until they abut against the second dies, and moving the second dies into their compression position whereby they press the blank, thus forming a tampon.

A machine embodying the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings in which:—

Figure 1 is a plan view of the machine;

Figures 2 to 5 show individual operating stages of the machine of Figure 1; and

Figures 6 and 7 respectively show the loading in of a blank and the ejection of a compressed tampon using the machine of Figure 1.

The machine shown in Figure 1 has a set of first pressing dies, containing n number of dies, wherein n is four which are symmetrically arranged about a central axis 10 and movable theretowards, each die 1 having two adjoining pressing surfaces 12 and 13, which intersect at an angle of 90° ($360°/n=360°/4$) to define a pressing edge 11 extending parallel to the axis 10. A set of second pressing dies 2 also n in number, n being four, are disposed one between each adjacent pair of the dies 1 around axis 10, for movement towards the axis 10, in the clearance space between the first dies 1, each die 2 having on its face nearest the axis 10 a concave pressing surface 14 in the form of a groove or shallow concavity extending parallel to axis 10. At the ends of each pressing surface 12 and 13 on the dies 1 are free edges 25 and 24, respectively. Each die in the first set 1 is carried at the inner end of a double-armed bell crank 21 mounted for pivotal movement about a pivot axis 23, the axis 23 being arranged generally in a square around centre axis 10. The arms of crank 21 are linked together on three sides by links 19 and on the fourth side by a triangular link 17 which is connected at its apex to an operating rod 15 so that as rod 15 is reciprocated, the dies of set 1 move together equally in concert toward or away from axis 10. Similarly each of the dies of set 2 is carried at the inner end of a double-armed bell-crank 22 which is also pivoted about the axis 23 of the crank 21 for an adjacent die of set 1 and the arms of crank 22 are linked on three sides by links 20 and on the front side by triangular link 18 connected to operating rod 16. Thus, as rod 16 reciprocates, the dies of set 2 swing towards or away from axis 10 equally in concert as a unit.

The pivot axes 23 are all located the same distance away from the axis 10, which distance is indicated by R (see Fig. 2), while the distance between adjacent pivots 23 is

$$2R \, . \sin \frac{\pi}{4} = 2R \, . \, \tfrac{1}{2}\sqrt{2} = \sqrt{2} \, . \, R.$$

During manufacture of the tampon, a substantially cylindrical tampon blank 6 is introduced between the dies of sets 1 and 2 while the latter are retracted away from the axis 10. The distance R must be greater than half the diameter D of the blank 6 (see Fig. 2), in order to provide sufficient space for the blank 6 to be received. Furthermore, R must be at least

$$\frac{D}{4}\left\{k + \left(1 + \sin \frac{\pi}{4}\right)\right\} c^2/k \text{ wherein } k = \frac{1 - c \sin \frac{\pi}{4}}{1 - \sin \frac{\pi}{4}}$$

and $c=2r_1/D$, r_1 being the smallest distance of the external surface of a fully compressed tampon 8 (in Figs. 4 and 5) from the centre of the tampon 8, i.e. for example the distance between the axis 10 and the bottom of one of the four peripheral grooves seen on the tampon 8 in Fig 4 (corresponding to edge 11 or dies 1). The last-mentioned requirement arises from the fact that free edges 24 of surfaces 13 of the first dies 1 need not touch the blank 6 during pivoting of the first dies 1. For $n=4$, R is at least $0.854\ D-1.207\ r_1+0.5\ r_1^2/D$. Both requirements, i.e. the last-mentioned requirement and the fact that R must be greater than D/2, are fulfilled in the machine illustrated in Fig. 1, where $R \approx 1.6\ D$.

The two surfaces 12 and 13 of the first dies 1 are both arcuate and generally converge at an inclined angle equal to $360/n°$. As mentioned, each first die 1 is associated with a second die 2 pivotable along with the associated first die 1 about a common pivot axis 23. The surface 12 of each first die 1 is convex and has a radius of curvature of at least p . R, wherein

$$p = \sqrt{1 - r_1^2/2\,R^2} - r_1/\sqrt{2}.R,$$

and r_1 is as hereinbefore defined. The centre of curvature of this surface is coincident with the pivot axis 23 for the corresponding die 1. The angle of arc which determines the effective length of surface 12 between edges 11 and 25 must, when $n=4$, be at least

$$\alpha_{min} = \text{arc cos} \, . \left\{ \tfrac{1}{2}\left(p + \frac{1}{p}\right) - D^2/8\,p\,R^2 \right\} - \text{arc sin} \, \frac{r_1}{\sqrt{2}R} \, .$$

This requirement arises from the fact that the free edges 25 of the convex surface 12 of the first dies 1 should be spaced a distance of at least D/2 from axis 10 when the dies 1 are in the fully pivoted position (see Fig. 3). This is because the pivotal movement of the dies 1 does not substantially reduce the effective diameter of the portions of the blank 6 remaining in the gaps between the co-operating surfaces 12 and 13 of adjacent dies 1. As an approximation, this last requirement can be expressed by stating that the minimum arc angle α_{min} for n=4 is $28.7° . D/R_p-40.5°\ r_1/R$ This requirement is fulfilled in the illustrated machine when the arc angle of the surface 12 is 17.2° and this is only approximately 2° more than the minimum arc angle α_{min} of 15.2° required in the present case.

Each pressing surface 13 of the first dies 1 is concave with a radius of curvature of at least (p+2q) R, in which

$$p = \sqrt{1 - r_1^2/2R^2} - r_1/\sqrt{2}.R,$$

$q=r_1/\sqrt{2}.R$, and r_1 is as hereinbefore defined. The free edges 24 of the concave surfaces 13 of the first dies 1 should be at a distance of at least D/2 from axis 10 after pivoting of the first dies 1. This is for the same reason explained above for surfaces 12. This requirement, however, leads to a rather smaller angle of arc, i.e. less than α_{min}, for the surface 13, as the radius of curvature of its surface is greater than the radius of curvature of the convex surface 12 by $\sqrt{2}.r_1$.

If only this minimum requirement were fulfilled for the arc angle of the concave sector forming surface 13, after pivoting of the first dies 1, the inner grooved edges of the dies 2 would be further away from the axis 10 than the edge 24, so that a gap or space would remain between the free edge 24 of surface 13 and the adjacent or facing side of the adjoining die 2. This is undesirable because with compression of blank 6 during pivoting of dies 1, tampon material could protrude into this space, and this would lead to obstruction of free pivotal movement of dies 2. Naturally, dies 2 would cut off or pinch off this tampon material as they swing inwardly, and this cut off or pinched off material would accumulate in the machine and after a while it would cause breakdowns. Cutting off or pinching off of protruding tampon material by dies 2 would also cause asymmetrical loadings on the second dies 2, and thereby introduce considerable vibrations when the machine was operating. This again would lead to considerable increase in wear. A further reason why gaps are undesirable is that it would then be necessary to provide separate abutments for the first dies 1 for limiting the inward pivotal movement. If the pressing surfaces 12 are long enough to simply abut against the second dies 2 at the end of their movement, separate abutments can be dispensed with. For the reasons indicated above, the arc angle of the surface 13 is also preferably at least α_{min}. The arc angles α and β of the two surfaces 12 and 13 of each first die 1 are preferably greater than α_{min}. This can also be fulfilled by the machine illustrated in Fig. 1, where $\alpha_{min}=15.2°$ and $\alpha=17.2°$, and $\beta=16.5°$. For reasons of symmetry, it is of advantage if the two angles α and β are generally equal in magnitude, in particular if the second dies 2 are also to operate as abutments for limiting the pivotal inward movement of the first dies 1.

Each die 2 is a hollow cylindrical sector with an annular thickness of at least $\sqrt{2}.r_1$, the radius of curvature of the concave surface being at least p . R and the radius of curvature of the convex surface being at least (p+2q) R, where

$$p = \sqrt{1 - r_1^2/2R^2} - r_1/\sqrt{2}.R,$$

and $q=r_1/\sqrt{2}.R$. The centre of curvature of this annular cylindrical sector coincides with the pivot axis 23 for the particular second die 2. The inner edge face of this sector towards the axis 10 is concave and forms the groove-like pressing surface 14 of the second die 2. The depth of the groove of surface 14 should be at least $r_a-r_1/\sqrt{2}$, where r_a denotes the maximum distance between the external surface of a fully compressed tampon 8 and the centre of the tampon 8, (i.e. half the greater diameter of the tampon 8 in Fig. 4), and r_1 is as hereinbefore defined. Furthermore, surface 14 is curved symmetrically relative to its centre and is advantageously cylindrical with a radius of curvature r_1. In this case, r_a will be equal to r_1, i.e. the blank 6 is compressed to a dense cylindrical form of diameter $2.r_1$. If, on the other hand, definite grooves are desired in the peripheral surface of the tampon between its four external surface sectors defined by the grooves 14, r_a should be greater than r_1, and the pressing surface 14 is then advantageously in the form of a sector sym-

metrical with the great elliptic half-axis of the surface of an elliptical cylinder, or of parabolic cross-section.

It is preferable that the arc angle of the hollow cylindrical sector forming a second pressing die 2 is greater than the arc angles determining the two pressing surfaces of a first pressing die 1. The double armed bell crank 22 supporting the second die 2 can then be fixed at the rear end of the second die 2 and so simplifies the construction as the double-armed bell crank 21 supporting the first dies 1 can be mounted above the double armed bell crank 22 supporting the second dies 2.

The drive rods 15 and 16 are movable alternately in an axial direction, for example pneumatically by compressed air cylinders, magnetically by electro-magnets, or by eccentric discs and an electric motor, preferably a stepping motor, in rhythm with the required opening and closing movement of the die sets 1 and 2. Linear movements of the drive rods 15 and 16, with the aid of coupling members 17, 19 and 18, 20, respectively plus the double arms at the rear end of each crank 21 or 22, are converted into corresponding pivotal movement for these arms and thereby of the respective dies 1 and 2.

Figs. 2 to 5 show various stages of movement of the dies 1 and 2.

Initially, each set of dies 1 and 2 are in their open or separated position shown in Fig. 2. A tampon blank 6 is loaded as Fig. 6 shows, by a two-part punch 3, 4 into the space between the open sets of dies 1 and 2. The punch 3, 4 is withdrawn after loading, so that the end surface of the cylindrical punch member 4 is in substantially the same vertical plane as the upper walls of dies 1 and 2.

The set of first dies 1 are then pivoted into the compression position shown in Fig. 3, whereby the blank 6 is compressed to intermediate conformation 7 which is substantially stelliform (i.e. cross-shaped) in cross-section. The paths followed by the dies 1 in this operation are shown by chain lines in Fig. 2 and by arrows in Fig. 3. The pressing forces caused by this movement do not pass through the central region of the blank 6, and in practice only the "arms" of the cross-shaped intermediate conformation 7, generated from the blank 6 are compressed in a direction generally transverse to their length. After pivoting the first dies 1, tampon material in the central area of the cross-shaped conformation 7 has not been compressed, while tampon material in the arms of the cross-shaped conformation 7, has been compressed substantially, i.e. by a factor of 2.25.

After pivoting of the first dies 1 is complete, the set of second dies 2 are pivoted into their compression position shown in Fig. 4. The cross-shaped conformation 7 is then compressed to the final tampon 8, which can be seen in Fig. 4. The movement performed by the dies 2 will clearly be seen on comparing Figs. 3 and 4. It will also be seen from Fig. 3, that the end pressing surfaces of the dies 2 are not directed exactly towards the centre of the intermediate conformation 7 at the start of pivoting of the dies, so that pressing forces acting directly against the centre of the pressed blank only arise during a latter portion of movement of the dies 2. In the present case, this latter portion is a relatively large proportion of the overall movement of the second dies 2, because the ratio R/D is selected to be 1.6, which is relatively high. By reducing the ratio R/D, e.g. to 0.7 to 0.8, this latter portion of movement is substantially reduced and amounts, for example, to only 15 to 30% of the overall extent of movement. On pivoting the second dies 2, tampon material is compressed principally in edge areas, to a smaller or greater extent depending on the ratio of R/D, while compression at the centre of the fully compressed tampon 8 is smaller than in those produced with the known machines referred to hereinbefore.

When the second dies 2 are completely pivoted, the pressing process is complete, and the dies 1 and 2 can be returned to their respective starting positions shown in Fig. 1. Early in this pivoting-away process, and therefore while the dies are substantially in the position shown in Fig. 5, the completed tampon 8 is ejected by means of the cylindrical punch member 4 which can have a nose 9, as shown in Fig. 7. After the dies 1 and 2 have returned to the respective positions shown in Fig. 1, a new pressing process can then begin.

Using the described machine, it is possible to achieve thickening or compression of tampon material in edge areas of the tampon which are evenly distributed around the periphery of the tampon. As a result, the tampons have a substantially improved resistance to buckling. The compressive forces of the first pressing dies 1 are not applied directly against the central areas of the tampon being manufactured, rather they follow lines offset from this central area. Furthermore, the compressive forces created subsequently by the second dies 2 are initially inclined away from this central area and are not directed towards the exact centre of the tampon until near

the end of the movement of the second dies 2. Consequently, only minimum compression of the tampon material takes place in the central area of the tampon. When using the previously known machine referred to above, the compressive forces of the first pressing dies act directly against the central areas of the tampon being manufactured and are greater by a factor of

$$\cos\frac{\pi}{n}$$

times the compressing forces in the herein described machine. Furthermore, the compressive forces caused by the second dies are also directed directly against the centre of the tampon, which naturally results in a considerably higher compression of the tampon material at the centre and a correspondingly smaller compression in the external edge areas thereof than results with the herein specifically described machine. As a result, the buckling resistance of tampons manufactured by the herein described machine is considerably greater than that of tampons manufactured using the previously known machine referred to above.

Preferably n is at most equal to 6, and the distance R of the pivot axes from the central axis of the machine is greater than

$$\frac{D}{4(1-\sin\frac{\pi}{n})}.$$

WHAT WE CLAIM IS:—

1. A machine for manufacturing tampons by pressing a substantially cylindrical elongate blank of wound wadding fleece in direction generally radially to the axis of the blank, the machine comprising a set of n first pressing dies, n not being 1 or 2, disposed around a central axis and pivotally movable towards said central axis to a compression position, each first die having two arcuate pressing surfaces respectively of concave and convex form which converge at an inclined angle of 360°/n towards a pressing edge extending parallel to said central axis the mutually facing pressing surfaces of each adjacent pair of dies defining therebetween an arcuate gap when the dies are in their compression position; a set of n second pressing dies equal in number to the first pressing dies, arranged alternately with the first pressing dies around the central axis and also pivotally movable towards the said axis, each second die being movable within one of the said arcuate gaps and having a concave pressing surface facing the central axis formed by a groove extending parallel to the said central axis; first and second drive means for respectively moving the first and second pressing dies towards said central axis; and first and second coupling means for coupling the dies within each set together so that corresponding points on each die within a set are at equal distances from the said central axis; all first and second pressing dies being mounted for pivotal movement towards the said central axis about pivot axes parallel to the central axis, each first and an adjacent second pressing die sharing a common pivot axis, the said pivot axes being spaced at a distance R from the central axis and at a distance

$$2R\sin\frac{\pi}{n}$$

from adjacent pivot axes, wherein R is greater than

$$\frac{D}{2}$$

and at least

$$\frac{D}{4}\left\{k+(1+\sin\frac{\pi}{n}\right\}c^2/k\ ,$$

each convex surface of each first pressing die having a centre of curvature coincident with the pivot axis of that pressing die and a radius of curvature of at least p . R and extending for an angle of arc of at least α_{min} where

1548714 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

Fig. 1

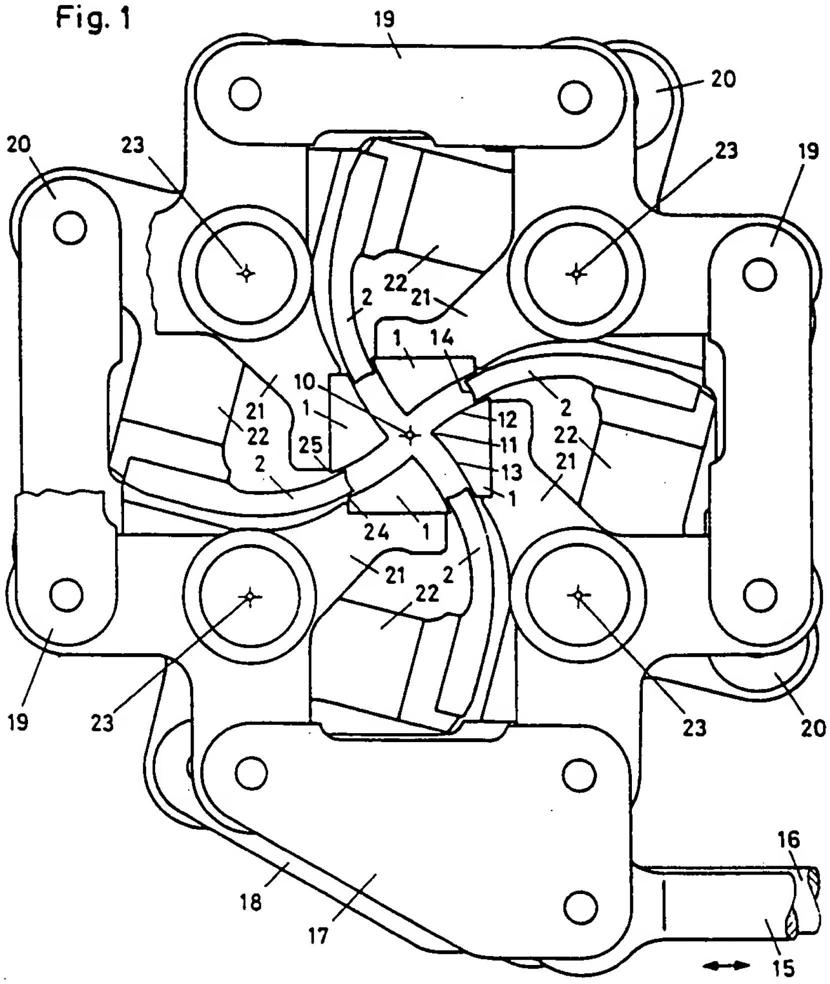


Fig. 2

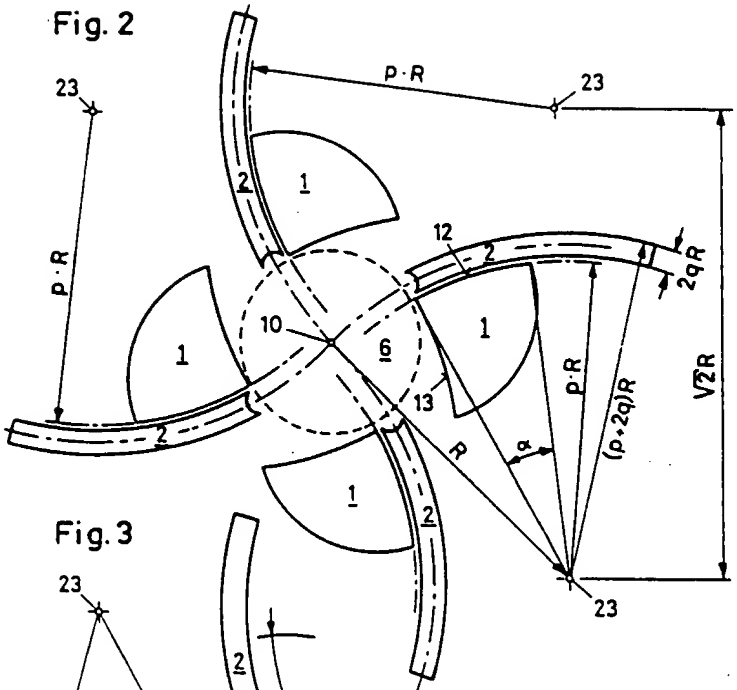

23
p·R
23
p·R
1
2
1
12
2
2qR
10
6
1
1
13
p·R
(p+2q)R
√2R
2
α
R
1
2
23

Fig. 3

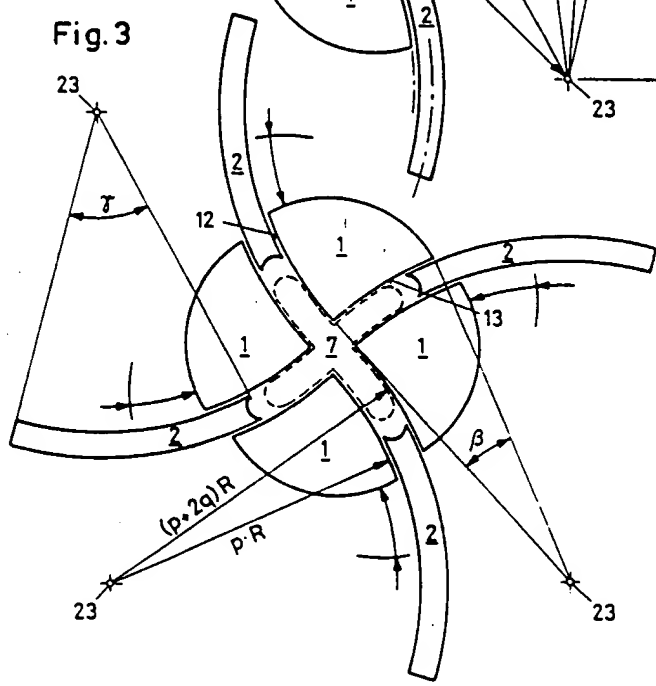

23
γ
2
12
1
2
13
1
7
1
2
1
β
(p+2q)R
p·R
2
23
23

Fig. 4

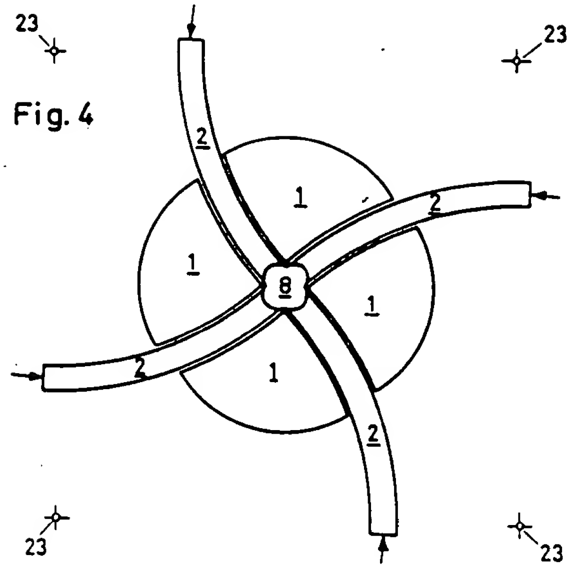


Fig. 5

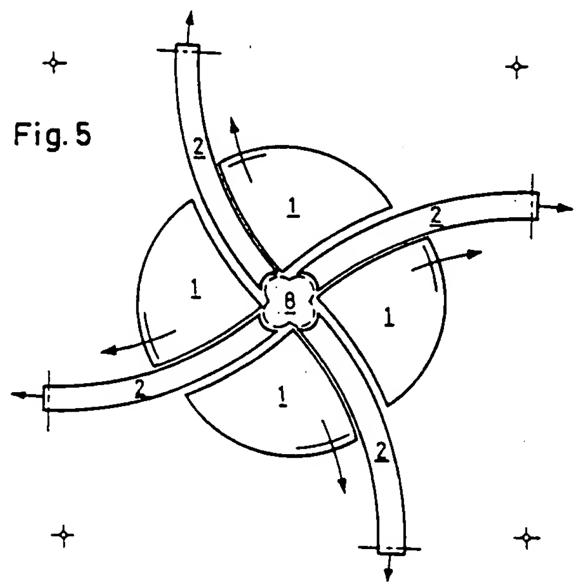


Fig. 6

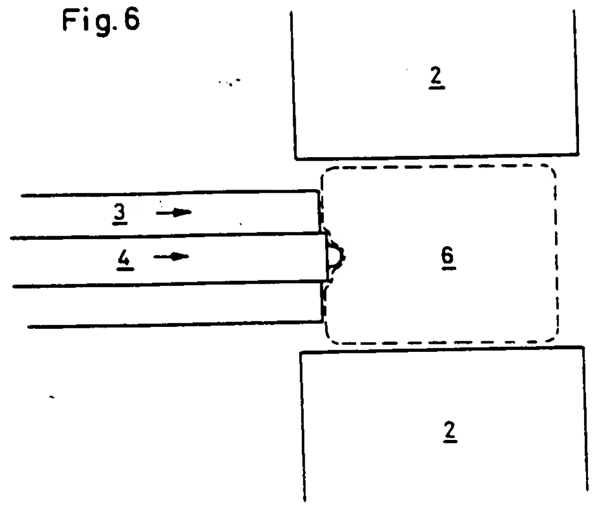
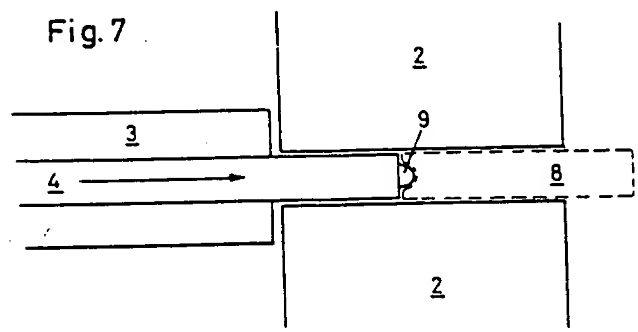


Fig. 7



$$\alpha_{min} = \text{arc cos} \left\{ \tfrac{1}{2} \left(p + \tfrac{1}{p}\right) - \tfrac{d}{p} \right\} - \text{arc sin } q,$$

and the concave surface having a radius of curvature of at least

$$\left\{ p + 2q \tan \frac{\pi}{n} \right\} R,$$

each second pressing die being an arcuate sector of an annulus having a wall thickness of at least

$$2q \tan \frac{\pi}{n} . R,$$

the concave and convex surfaces of each second die having radii of curvature of at least p . R, and

$$\left\{ p + 2q \tan \frac{\pi}{n} \right\} R,$$

respectively with both surfaces having a centre of curvature coincident with the pivot axis of the die, the groove of the concave pressing surface of each second die having a depth of at least (b−q) R, wherein

$$p = \sqrt{1 - q^2} - q \tan \frac{\pi}{n}$$

and

$$q = a \cos \frac{\pi}{n},$$

and furthermore $a = r_i/R$, $b = r_a/R$, $c = 2r_i/D$, $d = D^2/8R^2$ and

$$k = \frac{1 - c \sin \dfrac{\pi}{n}}{1 - \sin \dfrac{\pi}{n}},$$

while D is the diameter of the blank, and r_i is the smallest and r_a the greatest distance between the external surface and the centre of the fully compressed tampon.

2. A machine according to claim 1, wherein *n* is at most equal to 6, and the distance R of the pivot axis from the central axis is greater than

$$\frac{D}{4\left(1 - \sin \dfrac{\pi}{n}\right)}.$$

3. A machine according to either of the preceding claims, wherein the concave surface of each first die extends for an angle of arc of at least α_{min}.

4. A machine according to any of the preceding claims, wherein the sector angle of the annular cylindrical sectors forming each second die is greater than the arc angles of the two pressing surfaces of each first die.

5 A machine according to claim 3, wherein the arc angles defining the lengths of the two arcuate pressing surfaces of each first pressing die are equal in magnitude.

6. A machine according to any of the preceding claims, having a two-part punch for pushing-in the blank between the pressing dies and for pushing-out a pressed tampon, the punch being coaxial with said central axis and movable axially thereof, and comprising an inner cylindrical punch member having a diameter at least approximately $2r_a$, and a hollow outer cylindrical punch member around the cylindrical punch member, the internal diameter of the hollow punch member being at least approximately $2r_a$, and drive means for moving the two punch members.

7. A machine according to claim 6, wherein the two punch members have coplanar surfaces for simultaneous movement to push in the blank, and the cylindrical

punch member is movable relative to the hollow cylindrical punch member for pushing the pressed tampon out of the machine.

8. A machine according to claim 7, wherein the cylindrical punch member has a nose protruding from a central portion of its surface.

9. A method of manufacture of a tampon using a machine according to any of the preceding claims, which comprises positioning the first and second dies outwardly from the central axis, displaced at an angle of at least α_{min} relative to their compression positions, the second dies being displaced at an angle which is less than the arc angle defining the concave pressing surfaces of the first dies, pushing a blank into the central space between the pressing dies, pivotally moving the first dies inwards until they abut against the second dies, and moving the second dies into their compression position whereby they press the blank, thus forming a tampon.

10. A machine according to claim 1 substantially as herein described with reference to the accompanying drawings.

11. A method of manufacture of a tampon substantially as herein described with reference to the accompanying drawings.

12. A tampon manufactured using a machine according to any of claims 1 to 9 and 11 or a method according to claim 9 or claim 11.

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